5.1
Stream Flow

What is stream flow and why is it important?

Stream flow, or discharge, is the volume of water that moves over a designated point over a fixed period of time. It is often expressed as cubic feet per second (ft^3/sec).

The flow of a stream is directly related to the amount of water moving off the watershed into the stream channel. It is affected by weather, increasing during rainstorms and decreasing during dry periods. It also changes during different seasons of the year, decreasing during the summer months when evaporation rates are high and shoreline vegetation is actively growing and removing water from the ground. August and September are usually the months of lowest flow for most streams and rivers in most of the country.

Water withdrawals for irrigation purposes can seriously deplete water flow, as can industrial water withdrawals. Dams used for electric power generation, particularly facilities designed to produce power during periods of peak need, often block the flow of a stream and later release it in a surge.

Flow is a function of water volume and velocity. It is important because of its impact on water quality and on the living organisms and habitats in the stream. Large, swiftly flowing rivers can receive pollution discharges and be little affected, whereas small streams have less capacity to dilute and degrade wastes.

Stream velocity, which increases as the volume of the water in the stream increases, determines the kinds of organisms that can live in the stream (some need fast-flowing areas; others need quiet pools). It also affects the amount of silt and sediment carried by the stream. Sediment introduced to quiet, slow-flowing streams will settle quickly to the stream bottom. Fast moving streams will keep sediment suspended longer in the water column. Lastly, fast-moving streams generally have higher levels of dissolved oxygen than slow streams because they are better aerated.

This section describes one method for estimating flow in a specific area or reach of a stream. It is adapted from techniques used by several volunteer monitoring programs and uses a float (an object such as an orange, ping-pong ball, pine cone, etc.) to measure stream velocity. Calculating flow involves solving an equation that examines the relationship among several variables including stream cross-sectional area, stream length, and water velocity. One way to measure flow is to solve the following equation:

$$\text{Flow} = \frac{A\,L\,C}{T}$$

Where:

A = Average cross-sectional area of the stream (stream width multiplied by average water depth).

L = Length of the stream reach measured (usually 20 ft.)

C = A coefficient or correction factor (0.8 for rocky-bottom streams or 0.9 for muddy-bottom streams). This allows you to correct for the fact that water at the surface travels faster than near the stream bottom due to resistance from gravel, cobble, etc. Multiplying the surface velocity by a correction coefficient decreases the value and gives a better measure of the stream's overall velocity.

T = Time, in seconds, for the float to travel the length of L

How to Measure and Calculate Stream Flow

TASK 1 **Prepare before leaving for the sampling site**

Refer to pages 19-21 for details on confirming sampling date and time, safety considerations, checking supplies, and checking weather and directions. In addition to the standard sampling equipment and apparel, when measuring and calculating flow, include the following equipment:

- Ball of heavy-duty string, four stakes, and a hammer to drive the stakes into the ground. The string will be stretched across the width of the stream perpendicular to shore at two locations. The stakes are to anchor the string on each bank to form a transect line.
- Tape measure (at least 20 feet)
- Waterproof yardstick or other implement to measure water depth
- Twist ties (to mark off intervals on the string of the transect line)
- An orange and a fishing net (to scoop the orange out of the stream)
- Stopwatch (or watch with a second hand)
- Calculator (optional)

TASK 2 **Select a stretch of stream**

The stream stretch chosen for the measurement of discharge should be straight (no bends), at least 6 inches deep, and should not contain an area of slow water such as a pool. Unobstructed riffles or runs are ideal. The length that you select will be equal to *L* in solving the flow equation. Twenty feet is a standard length used by many programs. Measure your length and mark the upper and lower end by running a transect line across the stream perpendicular to the shore using the string and stakes (Fig. 5.4). The string should be taut and near the water surface. The upstream transect is Transect #1 and the downstream one is Transect #2.

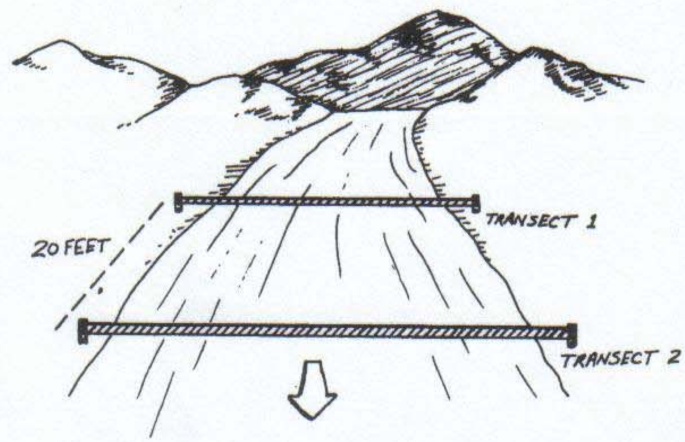

Figure 5.4

A diagram of a 20- foot transect

TASK 3 **Calculate the average cross-sectional area**

Cross-sectional area (*A* in the formula) is the product of stream width multiplied by average water depth. To calculate the average cross-sectional area for the study stream reach, volunteers should determine the cross-sectional area for each transect, add the results together, and then divide by 2 to determine the average cross-sectional area for the stream reach.

To measure cross-sectional area:

1. Determine the average depth along the transect by marking off equal intervals along the string with the twist ties. The intervals can be one-fourth, one-half, and three-fourths of the distance across the stream. Measure the water's depth at each interval point (Fig. 5.5). To calculate average depth for each transect, divide the total of the three depth measurements by 4. (You divide by 4 instead of 3 because you need to account for the 0 depths that occur at the shores.) In the example shown in

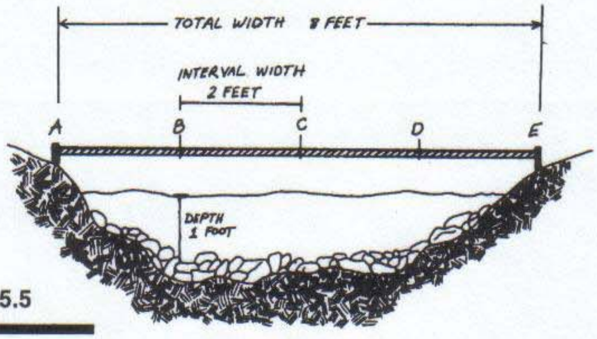

Figure 5.5

A cross section view to measure stream width and depth

Figure 5.6, the average depth of Transect #1 is 0.575 feet and the average depth of Transect #2 is 0.625 feet.

2. Determine the width of each transect by measuring the distance from shoreline to shoreline. Simply add together all the interval widths for each transect to determine its width. In the Figure 5.6 example, the width of Transect #1 is 8 feet and the width of Transect #2 is 10 feet.

3. Calculate the cross-sectional area of each transect by multiplying width times average depth. The example given in Figure 5.6 shows that the average cross-sectional area of Transect #1 is 4.60 square feet and the average cross-sectional area of Transect #2 is 6.25 square feet.

4. To determine the average cross-sectional area of the entire stream reach (*A* in the formula), add together the average cross-sectional area of each transect and then divide by 2. The average cross-sectional area for the stream reach in Figure 5.6 is 5.42 square feet.

Figure 5.6

A sample calculation of average cross-sectional area.

Determining Average Cross-Sectional Area (A)

Transect #1 (upstream)

	Interval width (feet)	Depth (feet)	
	A to B = 2.0	1.0	(at B)
	B to C = 2.0	0.8	(at C)
	C to D = 2.0	0.5	(at D)
	D to E = 2.0	0.0	(shoreline)
Totals	8.0	2.3	

Average depth = 2.3 / 4 = 0.575 feet

Cross-sectional area of Transect #1

= Total width X Average depth
= 8 ft X 0.575
= 4.60 ft²

Transect #2 (downstream)

Interval width (feet)	Depth (feet)	
A to B = 2.5	1.1	(at B)
B to C = 2.5	1.0	(at C)
C to D = 2.5	0.4	(at D)
D to E = 2.5	0.0	(shoreline)
10.0	2.5	

Average depth = 2.5 / 4 = 0.625 feet

Cross-sectional area of Transect #2

= Total width X Average depth
= 10.0 ft X 0.625
= 6.25 ft²

Average area = (Cross-sectional area of Transect #1 + Cross-sectional area of Transect #2) / 2

= (4.60 ft² + 6.25 ft²) / 2
= 5.42 ft²

Task 4 **Measure travel time**

Volunteers should time with a stop-watch how long it takes for an orange (or some other object) to float from the up-stream to the downstream transect. An orange is a good object to use because it has enough buoyancy to float just below the water surface. It is at this position that maximum velocity typically occurs.

The volunteer who lets the orange go at the upstream transect should position it so it flows into the fastest current. The clock stops when the orange passes fully under the downstream transect line. Once under the transect line, the orange can be scooped out of the water with the fishing net. This "time of travel" measurement should be conducted at least three times and the results averaged—the more trials you do, the more accurate your results will be. The averaged results are equal to *T* in the formula. It is a good idea to float the orange at different distances from the bank to get various velocity estimates. You should discard any float trials if the object gets hung up in the stream (by cobbles, roots, debris, etc.)

Task 5 **Calculate flow**

Recall that flow can be calculated using the equation:

$$\text{Flow} = \frac{A\,L\,C}{T}$$

Continuing the example in Fig. 5.6. say the average time of travel for the orange between Transect #1 and #2 is 15 seconds and the stream had a rocky bottom. The calculation of flow would be:

A = 5.42 ft^2

L = 20 ft

C = 0.8 (coefficient for a rocky-bottom stream)

T = 15 seconds

$$\text{Flow} = \frac{(5.42\ ft^2)\ (20\ ft)\ (0.8)}{15\ sec.}$$

$$\text{Flow} = \frac{86.72\ ft^3}{15\ sec.}$$

$$\text{Flow} = 5.78\ ft^3/sec.$$

Task 6 **Record flow on the data form**

On the following page is a form volunteers can use to calculate flow of a stream.

References

Adopt-A-Stream Foundation. *Field Guide: Watershed Inventory and Stream Monitoring Methods,* by Tom Murdoch and Martha Cheo. 1996. Everett, WA.

Mitchell, M.K., and W. Stapp. *Field Manual for Water Quality Monitoring.* 5th Edition. Thompson Shore Printers.

Missouri Stream Teams. *Volunteer Water Quality Monitoring.* Missouri Depart-ment of Natural Resources, P.O. Box 176, Jefferson City, MO 65102.